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An Enhanced LPI Control Mechanism for Ethernet Access Networks

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Abstract. Ethernet is the most widely deployed access network technology around the world. IEEE 802.3az working group confirmed EEE standard based on LPI mode in order to enhance the energy efficiency on Ethernet. In this paper, we suggest an enhanced LPI Control Mechanism for Ethernet access networks. Simulation results show that our mechanism improves the overall performance by reducing the energy consumption rate compared to the existing mechanisms.

Keywords: Traffic Control, Energy Efficient Ethernet, Enhanced LPI mechanism, IEEE 802.3az, Ethernet access networks

1 Introduction

Ethernet is one of the most widely- deployed and utilized local-loop networking technology. With the use of energy efficient protocol on Ethernet, about 3 TWh per year can be saved from wasting. Furthermore, it is expected that energy consumption costs would be reduced by $400 million per year only in U.S. and over $1 billion per year around the world [1]. IEEE 802.3az working group set out the formation of the standard for Energy Efficient Ethernet (EEE) since early 2007. On September in 2010, standard applying low power idle (LPI) mechanism was released[2]. LPI is a mechanism to protect the energy from unnecessarily being wasted by switching the corresponding Ethernet link status to idle mode when it has no frames to transfer [3][4]. Periodically paused switched Ethernet (PPSE) was previously proposed to enhance energy efficiency in small-sized Ethernet switch[3]. PPSE mechanism is not suitable for transmitting real-time multimedia data properly. To overcome this challenge, adaptive PPSE mechanism was suggested. While the traditional mechanism has a fixed time interval staying in ON or OFF state, the adaptive PPSE considers past traffic load to determine whether to put the switch in ON or OFF state [3]. This paper suggests an enhanced LPI Control Mechanism to improve the energy

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efficiency for Ethernet access networks. This mechanism determines ON and OFF periods of consecutive cycles based on the measured incoming traffic quantities from the terminals within a certain period. It offers adaptive LPI control mechanism in proportional to the traffic load by conducting synchronous data transfer to the switch, upon conveying ON, OFF period information to the switch.

2 Enhanced LPI Control Mechanism

To alleviate the problems of adaptive PPSE as mentioned above, this study proposes Synchronizing Adaptive LPI Control Mechanism. This mechanism segregates every individual port status of Ethernet switch and network interface card by ON or OFF state. Transmission and reception of packets are called off at OFF state owing to power blocking of most components, whereas normal transmitting and receiving are possible at ON state. The switch leads operation with a certain type of recursive cycle, and this paper defines this operation as a default cycle. The default cycle comprises of duration time (T_{cycle}) with certain constant value. T_{cycle} defines as sum of variables T_{on} and T_{off}. T_{off} means a time which a port stays at OFF state while T_{on} represents a time which continues to operate as ON. The switch has n ports comprising of (n-1) interface ports to the access network and one core network interface port. The start time of default cycle is synchronized to correctly coincide with all the links, and T_{on}, T_{off} durations of individual links have distinct values depending upon traffic quantities which come to corresponding links. That is, it resolves the issues of adaptive synchronous coupling mechanism by independently managing ON, OFF state transitions by links based on analysis of traffic characteristic of each link. It can improve energy efficiency due to its more concrete capability to correctly judge packet quantities to transmit at consecutive default cycles by performing forecasts on incoming traffic characteristic at the terminal node. This mechanism recursively conducts default cycle which is synchronized between switch and terminal device. This study takes an example of up-link traffic to explain the delivery of packets from terminal device to internet core network, even though Ethernet is of full-duplex communication. The first default cycle comprises of T_{on_def} and T_{off_def}, and it then operates every cycle in accordance with value T_{on}, T_{off} which have reflected the traffic status. Each terminal node evaluates the values T_{on}, T_{off} of default cycle, measuring packet quantities which have been received from application layer during OFF period of previous default cycle and stored at transmission queue. It figures out T_{on} value through calculating the estimated time to transfer the corresponding packets to the switch, considering total quantities of packets, capacity of transmission links and its overhead, and T_{on} value has the value of T_{on_def} multiplied by integer and should not exceed half of default cycle. The terminal node delivers T_{on} value to switch at the instant the default cycle begins. The switch decides T_{on} period of up-link transmitter at the internet core network based on T_{on} value of total links, once it receives T_{on} value from link. The terminal node cuts back on energy consumption by stopping transmitting packets and letting corresponding link to switch to LPI mode once it reaches the expiration of T_{on} period, while transmitting the packets loaded on transmission queue to the switch only for T_{on} period. The switch also reduces energy consumption by stopping packet reception and letting corresponding link to switch to LPI mode during $_{Toff}$ period once it reaches the expiration of $_{Ton}$ period, transmitting the received packets to the internet core network for $_{Ton}$ period.

3 Performance Evaluation

This study has conducted the performance analysis of suggested mechanism with simulations, using CSIM 20 simulator as a simulation tool[5]. It has performed modeling on traffic gathering from all links connected with switch as a link, applying the same network architecture as the previous study[3]. It has implemented the script determining ON, OFF state transition based on the estimated transmission rate of traffic through checking packet size of gathered link. 10Gbps has been given to Ethernet link capacity and 100msec for $_{Tcycle}$ for performance analysis. The incoming traffic pattern has implemented the script to determine the average arrival rate according to the set load, assuming that this traffic pattern follows Poisson distribution which has fixed packet with 1500 bytes. This study has measured the energy consumption rate and average packet delay by moving between interval with 1 ~ 30% of its traffic load for the suggested mechanism. Table 1 shows the energy consumption rates. The suggested mechanism in this study has shown to mark lower energy consumption rate than Adaptive PPSE for most range of traffic loads.

Table 1. Energy consumption

Traffic Load (port No)				Energy consumption (port No)			
1	2	3	4	1	2	3	4
0.02	0.02	0.02	0.02	14.5	14.5	14.5	14.5
0.02	0.04	0.06	0.08	14.5	14.5	19	19
0.02	0.06	0.08	0.1	14.5	19	19	20
0.02	0.08	0.1	0.12	14.5	19	20	23.4
0.02	0.1	0.12	0.14	14.5	20	23.4	23.4
0.02	0.12	0.14	0.16	14.5	23.4	23.4	25.5
0.02	0.14	0.16	0.18	14.5	23.4	25.5	27.9
0.02	0.16	0.18	0.2	14.5	25.5	27.8	27.9
0.04	0.02	0.02	0.02	14.5	14.5	14.5	14.5
0.04	0.02	0.04	0.04	14.5	14.5	14.5	14.5
0.04	0.04	0.06	0.08	14.5	14.5	19	19
0.04	0.06	0.08	0.1	14.5	19	19	20
0.04	0.08	0.1	0.12	14.5	19	20	23.4
0.04	0.1	0.12	0.14	14.5	19.8	23.4	23.4
0.04	0.12	0.14	0.16	14.5	23.4	23.4	25.5
0.04	0.14	0.16	0.18	14.5	23.4	25.5	27.9
0.04	0.16	0.18	0.2	14.5	25.5	27.9	27.9
0.06	0.02	0.02	0.02	19	14.5	14.5	14.5
0.06	0.02	0.04	0.04	19	14.5	14.5	14.5
0.06	0.04	0.06	0.08	19	14.5	19	19
0.06	0.06	0.08	0.1	19	19	19	20
0.06	0.08	0.1	0.12	19	19	19	23.4
0.06	0.1	0.12	0.14	19	19.8	23.4	23.4
0.06	0.12	0.14	0.16	19	23.4	23.4	25.5
0.06	0.14	0.16	0.18	19	23.4	25.6	27.9
0.06	0.16	0.18	0.2	19	25.4	27.9	28
0.08	0.02	0.02	0.02	19	14.5	14.5	14.5
0.08	0.02	0.04	0.04	19	14.5	14.5	14.5

0.08	0.02	0.04	0.06	19	14.5	14.5	19
0.08	0.04	0.06	0.08	19	14.5	19	19
0.08	0.06	0.08	0.1	19	19	19	19.8
0.08	0.08	0.1	0.12	19	19	19.8	23.4
0.08	0.1	0.12	0.14	19	19.9	23.4	23.4
0.08	0.12	0.14	0.16	19	23.4	23.4	25.4
0.08	0.14	0.16	0.18	19	23.4	25.6	27.9
0.08	0.16	0.18	0.2	19	25.5	27.9	27.9
0.1	0.02	0.02	0.02	19.8	14.5	14.5	14.5
0.1	0.02	0.04	0.04	19.7	14.5	14.5	14.5
0.1	0.02	0.04	0.06	19.7	14.5	14.5	19
0.1	0.04	0.06	0.08	19.8	14.5	19	19
0.1	0.06	0.08	0.1	19.8	19	19	19.8
0.1	0.08	0.1	0.12	20	19	19.9	23.4

4 Conclusion

This paper has suggested an enhanced LPI Control Mechanism to improve the energy efficiency between Ethernet network interface devices and Ethernet switches. This mechanism can address the issues that the existing adaptive synchronous coupling mechanism embraces because the switch performs LPI mode through adapting to the traffic loads. The analysis has shown that the suggested mechanism enhances the overall performance by reducing the energy consumption rate compared to the existing mechanism, keeping the similar average packet delay to the existing mechanism. The performance analysis has been going on for the environment that each link has different input traffic characteristic.

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References

1. Gunaratne, C., Christensen, K., Nordman, B., and Suen, S.: Reducing the energy consumption in Ethernet with Adaptive Link Rate (ALR)", IEEE Trans. Computers, vol. 57, no. 4, (2008), pp. 448-461.
2. Christensen, K. and Reviriego, P.: IEEE 802.az: the road to energy efficient Ethernet. Communications Magazine, IEEE, vol. 48, no. 11, (2010), pp. 50-56.
3. Mostowfi, M. and Christensen, K.: Saving energy in LAN switches: New methods of packet coalescing for Energy Efficient Ethernet", Green Computing Conference and Workshops (IGCC), (2011), pp. 1-8.
4. Odlyzko, A.: Data Networks are Lightly Utilized, and Will Stay That Way. Review of Network Economics, vol. 2, no. 3, (2003) September, pp. 210-237.
5. Schwetman, H.: CSIM19: A Powerful Tool for Building System Models. Proceedings of the 33rd Winter Simulation Conference, (2001) December, pp. 250-255.

